

## Chapter 2: Motion in One Dimension

- Motion
- Position and Displacement
- Average velocity and average speed
- Instantaneous velocity and speed
- Acceleration
- Constant acceleration: A special case
- Free fall acceleration
- In this chapter we will only look at motion along a straight line (one dimension).
- Motion can be forward (positive displacement) or backwards (negative displacement)

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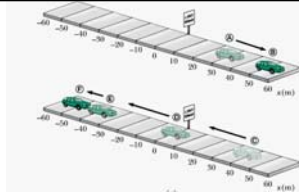
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### Position (x), Displacement ( $\Delta x$ ) and (total) distance traveled (d)



- Kinematics – branch of physics; study of motion
- Position ( $x$ ) – where you are **located**
- Distance (d) – how far you have traveled, regardless of direction
- Displacement ( $\Delta x = x_f - x_i$ ) – where you are in relation to where you started, need initial and final position.

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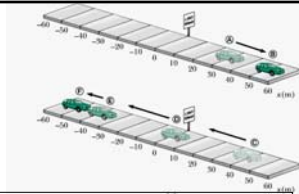
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### Displacement and total distance traveled



**Displacement** of a particle: Its change in position:

$$\Delta x \equiv x_2 - x_1$$

$x_2$  final position

$x_1$  initial position

**Displacement** is a **vector**: It has both, magnitude and direction!!

For one dimensional motion a +ve sign means the displacement is toward the right, a -ve sign means the displacement is toward the left.

Distance is a scalar, only magnitude.

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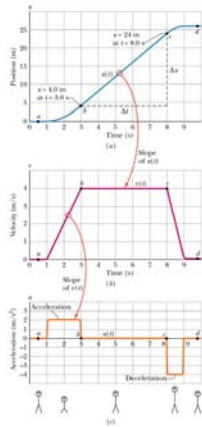
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**Sample Problem 2.2**

Relationship between acceleration-time graph and velocity-time graph and displacement-time graph.




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**One-dimensional motion with constant acceleration**

$$v = v_0 + at$$

$$x - x_0 = v_0 t + \frac{1}{2} at^2$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

$$x - x_0 = \frac{1}{2}(v_0 + v)t$$

$$x - x_0 = v t - \frac{1}{2} at^2$$

Missing quantity	
$x - x_0$	
$v$	
$t$	
$a$	
$v_0$	

Derivations:  
Book pp. 21-23

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**Sample Problem 2.4**

A particle's position is given by:

$$x = 4 - 27t + t^2$$

- (a) Find  $v(t)$  and  $a(t)$ .
- (b) Is there ever a time when  $v = 0$ ?
- (c) Describe the particle's motion for  $t \geq 0$ .

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**Sample Problem 2.5**

Spotting a police car, you brake a Porsche from a speed of 100 km/h to speed 80 km/h during a displacement of 88.0 m at a constant acceleration.

- (a) What is your acceleration?
- (b) How long did it take to slow down?

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**Freely falling objects**

In the absence of air resistance, all objects fall towards the earth with the same constant acceleration ( $a = -g = -9.8 \text{ m/s}^2$ ), due to gravity

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**Problem 38**

A Hoodlum throws a stone vertically downward with an initial speed of 12.0 m/s from the roof of a building 30.0 m above the ground:

- (a) How long does it take the stone to reach the ground.
- (b) What is the speed of the stone at impact.

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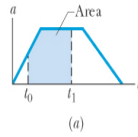
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**Graphical Integration in Motion Analysis**

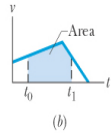
Because acceleration is defined in terms of velocity as  $a = dv/dt$ , we have:

$$v_1 - v_0 = \int_0^{t_1} a dt = \left( \begin{array}{l} \text{area between acceleration curve} \\ \text{and time axis, from } t_0 \text{ to } t_1 \end{array} \right)$$



Similarly, because  $v$  is defined in terms of the position  $x$  as  $v = dx/dt$ , then:

$$x_1 - x_0 = \int_0^{t_1} v dt = \left( \begin{array}{l} \text{area between velocity curve} \\ \text{and time axis, from } t_0 \text{ to } t_1 \end{array} \right)$$




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**Review:**

- Displacement  $x$ , velocity  $v$ , acceleration  $a$
- $a = dv/dt = d^2x/dt^2$ , and  $v = dx/dt$ .
- Know  $x$ ,  $v$ ,  $a$  graphs.  $x$  is slope of  $v$ -graph,  $v$  is slope of  $a$ -graph.
- For constant acceleration problems (most problems, free fall):

$$x = x_0 + v_0t + \frac{1}{2}at^2$$

$$v = v_0 + at$$

- Equations on page 23 (const. Acceleration & free fall).
- Free fall

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**Performance Objective**

1. Define what is meant by kinematics.
2. Define displacement and express it mathematically.
3. Distinguish between displacement and distance.
4. Define velocity and express it mathematically.
5. Distinguish between velocity and speed.
6. Solve word problems involving average speed and velocity.
7. Define acceleration and express it mathematically.
8. Explain what is meant by free-fall acceleration
9. Displacement ( $\Delta x$ ) and  $\Delta v$  from graphs.
10. Solve word problems involving constant acceleration.

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